

Erosion corrosions of materials in a marine environment engineering essay

[Engineering](#)



**ASSIGN
BUSTER**

On

School of Engineering

Systems Department Erosion-Corrosion of Materials in a Marine

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Chapter 1

1. 1 Abstract

Erosion-Corrosion is the complex phenomenon of solid particle erosion and electrochemical process of corrosion. One of the main areas it's been seen is the marine industry where the pipes, valves and vessels are exposed to the process leading them to wear and later to damage completely. A wide range of issues are thereby affected when selecting the appropriate materials for this specific use. When selecting a particular material the designer has to consider a number of constraints and parameters which solves the problems. Some of among them are slurry pot test rigs and submerged test conditions which will provide enough data to work with the selection of appropriate material. The aim of this work is to examine the wear rate caused in engineering materials like Copper, Brass and Stainless Steel. The study reveals the particle wear rate caused in the materials to classify them according to resistance to Erosion-Corrosion. The slurry pot tester is run at different speeds under different Erosive-Corrosive media to acquire test results which will accompany an SEM analysis to conclude the resistance levels.

1. 2 Acknowledgement

I would like to express my sincere gratitude and appreciation to all who gave me encouragement to successfully complete this final year project. Special thanks to my project supervisor Dr Mark S. Bingley, whose help, stimulating suggestions and valuable thoughts helped me to coordinate this project. I would also like to acknowledge the assistance by Dr Sabuj Mallik, who helped me generating microscopic images using SEM during analysis part for this project. Special thanks to assessor Dr Michael I. Okereke whose, findings and suggestions during presentation which improved the standard of this project. Also to thank is the staff of Mechanical laboratory in Hawke, who gave the permission to use the required tools to work with the experiments. Last but not least, many thanks to University of Greenwich faculty for providing laboratory and library facilities for the success and completion of this report.

1. 3 Aim of the Project

The fundamental aim of this project is to investigate the effect of Erosion and Corrosion in materials used in marine environments. Therefore, materials like Copper, Brass and Stainless Steel are tested and examined using a slurry pot tester under different particle-fluid conditions. The susceptibility is differed according to the type of material being used. The process will reveal the safe-unsafe flow conditions for the test materials used in marine environments.

1. 4 Objectives

To develop a theoretical understanding about Erosion-Corrosion processes.
Identifying the required equipment and resources for the test conditions.

Conduct an experiment involving different materials undergoing Erosion, Corrosion and Erosion-Corrosion process. Investigating the role of different parameters (flow velocity, sand size, test solution etc.) influencing Erosion-Corrosion. Collection of data to identify the variation of wear rate in materials undergone tests in different fluid-particle concentrations. Determining the synergy levels for each material and classifying them relative to its Erosion-Corrosion resistance. Microscopic analysis (SEM) to generate images which shows any spatial variations and surface roughening happened to the material. Concluding safe-unsafe flow conditions for the use of test specimen under flow conditions.

1. 5 Project Deliverables

Project proposal report
Experimental and analytical data
Determining safe-unsafe flow conditions for engineering materials
A detailed documented literature review on the project
Project logbook
Poster for presentation

Chapter 2

2. 1 Introduction

In the recent years, studies related to particle wear in engineering materials have received a substantial attention due to the rigorousness of problems created in relevant fields. Among them is the solid particle erosion-corrosion which affects the marine industry very much due to the damage caused to components like pipelines, valves, turbines, pumps etc. (Rajahram, Harvey, & Wood, 2009)The constant requirement for water to cool the heat exchangers in plants thereby uses the pipelines to supply flowing seawater at a specific rate. The sand particles in a particular shape and size which are

carried by a stream of seawater through the pipes are then combined to cause wear to the material exposed. The application of erosion-corrosion process starts from here as the sand particles acts as an erosive media whereas, the seawater normally with a pH of 7.8 to 8.2 and 3% NaCl acts as a corrosive media. The combined action of both the mediums results in the inner wall of pipes to degrade the material thus resulting in a failure after an average lifetime of 7 years. (Wood, Puget, Trethewey, & Stokes, 1998)

2.2 Marine Environment

Figure 2. 1: Corrosion damage to iron rods under a bridge

The marine industry can be broadly categorized into three different sections. Above water (ships and boats), under water (submarines, pipelines) and fixed main structures (wind mills). All the above three are exposed to factors which affects the degradation of materials. The main process to look out for is the corrosion damage which is occurred by the influence of saline water. Most of the engineering materials in marine industry are damaged as a result of corrosion mechanism. The vehicles and other components that are mostly used in seashore areas are exposed to the flowing saline water which gradually starts this process. The electrochemical process of corrosion thus starts in a specific area unless protected by coatings spreads to the other parts gradually thereby wearing out the material completely.[1] Unlike other industries, marine departments have only one thing in common, namely, that they operate in, or upon the surface of, a body of water. Also, the continuous requirement in supply of water in these areas exposes the materials to the process of erosion and corrosion. Components such as pipes, valves and other fittings are highly affected by this process and leads

to failure after average lifetime. Therefore materials in these areas have to be clearly identified according to its resistance to erosion and corrosion.

2.3 Applications

The research, experimental and analytical data recorded in this project aids to classify the engineering materials according to their erosion-corrosion resistance. Materials like copper, brass and stainless steel are mostly seen and used in marine fields. Especially copper components like valve fittings are pipes which are more likely to affect the process of both erosion and corrosion. The high resistive features for copper and brass in some cases are less likely to be seen in mechanisms of this kind. Stainless steel, however being more strong and stiff is nowadays used for components which are subjected to degradation techniques. The results generated in the study are enough to examine the hardness levels of the above materials which are subjected to three different test conditions. The fields most often seen with erosion and corrosion damage is marine industry where the flowing seawater combined with particles affecting the exposed material. Thus, both processes are examined and evaluated thoroughly to identify the factors affecting wear rates and flow concentrations which may have a role in the process.

Chapter 3

3.1 Theory of Erosion-Corrosion

MaterialDirection of fluid flowCorrosion filmImpingement corrosion
pitsOriginal surfaceFigure 3. 1: The Erosion-Corrosion processThe mechanical process of erosion and electrochemical process of corrosion are combined to known as Erosion-Corrosion in engineering materials. It occurs in materials

when solid particles interact with a corrosive liquid. Erosion occurs when solid particles carried by a stream of liquid or gas hits a target material causing it to deform or fracture. Corrosion on the other hand is the gradual destruction of material when it undergoes a chemical reaction with its environment. The process is most powerful in soft alloys such as, copper, aluminium, lead etc. The phenomenon is commonly seen in industries like oil and gas, mining, chemical and power where there is an interaction between both erosive and corrosive media resulting in the damage of components. Typical wear of components leads to either repair or replacements which is a liability for industries.(Rajahram, 2010)Turbulent flow process can destroy the protective films on a material and cause high corrosion rates, otherwise high resistant under static conditions. In a laminar flow, fluid flow rate has variable effect depending on the material. Cavitation is special factor in erosion-corrosion and is caused by formation and collapse of bubbles in liquid near to the material. It removes protective scales on the surface by the implosion of gas bubbles in a fluid causing the material to undergo corrosion.

3. 2 Synergism

The material which is subjected to the process of erosion-corrosion experiences an additional wear rate which is normally higher than the sum of wear caused by pure erosion and flow corrosion. This additional wear rate is termed as synergy. Synergism can be expressed as follows; (Rajahram, 2010)..... [Eqn. 1]..... [Eqn. 2]Where, T = Total wear due to erosion-corrosion
S = Additional wear caused due to synergistic effects
E = Wear due to pure erosion
C = Wear due to flow corrosion

3. 2. 1 Positive/Negative Synergy

The additional wear rate caused in materials due to synergistic effects can be either positive or negative depending on the rates of total wear rate (T), pure erosion (E) and flow corrosion (C). Positive synergism is often seen when the total wear rate of the material is higher than the sum of wear rates due to pure erosion and flow corrosion. Negative synergy is recorded when the sum of pure erosion and flow corrosion is higher than the total wear rate caused. This is termed as antagonism. (Rajahram, 2010)

3. 2. 2 Components of Synergism

The additional wear rate termed as synergy also consists of two main components which are as follows;..... [Eqn.

3]Where, S = Synergy
 ΔE = Corrosion enhanced erosion
 ΔC = Erosion

enhanced corrosion
 R. J. K. Wood [1] and S. P. Hutton [2] who carried out researches on synergism later went on to publish the two groups of synergy, which are medium and high synergy. Below equations are obtained for these two groups. (Rajahram, 2010)
 Medium Synergy group.....

[Eqn. 4]High Synergy group..... [Eqn. 5]

3. 2. 3 Corrosion enhanced erosion (ΔE)

Corrosion enhanced erosion is the phenomenon of cracking a material in pieces when multiple erodent impacts were subjected. A jet impingement test was used to conduct the corrosion enhanced erosion rate which was proposed by Y. Li, G. T. Burstein and I. M. Hutchings [3]. The study showed how corrosion enhances the erosion rates by attacking local targets which leads to propagation of the crack, making the surface susceptible to

detachment.(Rajahram, 2010)Similar researches and findings were proposed by A. Toro, A. Sinatora, D. K. Tanaka A. P. Tschiptschin [4] and A. Neville, T. Hodgkiess, H. Xu [5]. who approached the process experimentally. He performed tests on erosion-corrosion subjecting grey cast iron which strengthened the theory by F. Aiming, L. Jinming and T. Ziyun [6].

3. 2. 4 Erosion enhanced corrosion (ΔC)

Like the process of corrosion enhanced erosion, erosion enhanced corrosion affects a material at a particular region which is subjected to corrosion. The erosion wear affected to the material tend to favour the corrosion rate by destroying the surface continuously. The works put forward by M. M. Stack, S. Zhou and R. C. Newman [7] established an erosion-corrosion map which aided to detect the transition between erosion-corrosion regimes. The study figured the role of passive current density increased with higher velocity in the existence of erosive mediums. As the speed was increased, the passive current was then increased to rupture the surface of the material.

Chapter 4

4. 1 Solid Particle Erosion

The process of erosion reflects the contact between solid particles and a carrier fluid which can normally be a stream of liquid or a gas. The erosive media here referred to as solid particles are suspended in the carrier fluid which then on goes to impinge the material surface. The material is then subjected to continuous erosion by damaging the outer surface. This leads the material to either rupture completely or depending on several factors such as velocity of impact, size of particle etc. The main researches

conducted on solid particle erosion are based on the above factors namely, size and shape of solid particles, type and nature of flowing fluid and the type of material characteristics(Rajahram, 2010). Early researches and studies put forward by I. M. Hutchings [8] relates to the forces acting on a solid particle when it is contact with the material surface.